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Product Carbon Footprint Analysis

Product: Stainless Steel Dinner Spoon

Protocol Data (Accounting Standard): GHG Protocol

Senior Sustainability Consultant: Remko Weingarten

Product Carbon Footprint Report: Stainless Steel Dinner Spoon

Generated Date: April 17, 2026

Executive Summary

This report presents a detailed Product Carbon Footprint (PCF) analysis for a standard stainless steel dinner spoon, following the GHG Protocol standards, including the proposed 2026 Land Sector and Removals (LSR) Update and enhanced Scope 3 reporting requirements. The analysis adopts a "factory_gate" system boundary, focusing on the cradle-to-gate emissions for production in the Netherlands, with a supply chain focus on Europe. The primary objective is to quantify the greenhouse gas (GHG) emissions (expressed in CO2e) associated with the spoon\'s material acquisition, manufacturing, and associated upstream transport and waste generation, providing insights into emission hotspots and areas for potential reduction.

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1. Define Scope

Functional Unit

The functional unit for this analysis is **1.0 unit of a Stainless Steel Dinner Spoon**, weighing approximately 60 grams.

System Boundary

The system boundary is defined as **factory_gate (cradle-to-gate)**. This includes all processes from raw material extraction, upstream transportation, manufacturing processes at the production facility in the Netherlands, and any waste generated during production, up to the point where the finished spoon leaves the factory gate. Downstream impacts

such as consumer use, disposal, and end-of-life treatment are excluded from this boundary.

Geographic Scope

The final production country for the spoon is **The Netherlands**. The supply chain focus is broadly **Europe Focused**, meaning emission factors and transport distances are primarily representative of European averages or specific country data where available.

Accounting Standard

This PCF analysis strictly adheres to the **GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard**, alongside the **Corporate Standard**. Emissions are categorized into Scope 1 (direct emissions from owned or controlled sources), Scope 2 (indirect emissions from purchased energy), and Scope 3 (all other indirect emissions in the value chain). The report also incorporates considerations from the proposed 2026 Land Sector and Removals (LSR) Standard and the draft 95% Scope 3 coverage requirement.

- **2026 LSR Update:** The GHG Protocol Land Sector and Removals (LSR) Standard v1.0, effective January 1, 2027, provides requirements and guidance for land-based GHG emissions and carbon removals. While the direct land-use impacts for stainless steel are less prominent than for agricultural products, this standard acknowledges the importance of considering land-use changes and removals associated with raw material extraction in the broader value chain. Forest carbon accounting is not included in this version of the LSR Standard.
- **Scope 3 Compliance:** In line with proposed 2026 requirements, this analysis aims for at least 95% coverage for Scope 3 emissions. This means all significant upstream value chain activities are included, and any exclusions are carefully justified and do not exceed 5% of the total required Scope 3 emissions.

Allocation

Given that the functional unit is a single product (spoon), allocation challenges for co-products or by-products at the final manufacturing stage are minimized. For upstream material production, industry-average emission factors are used, which inherently include allocation methodologies applied by their respective databases (e.g., Ecoinvent) for

multi-output processes. Mass-based allocation is implicitly used where materials are accounted for by weight.

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2. Map Lifecycle (LCI Inventory Stages) & 3. Collect Data (Primary/Secondary Data Points)

The lifecycle of a stainless steel dinner spoon, within a cradle-to-gate boundary, can be broken down into the following key stages:

Material Acquisition & Production (Scope 3, Category 1: Purchased Goods and Services)

The primary material for a dinner spoon is stainless steel. For this analysis, we assume 18/8 grade stainless steel, a common alloy. The production of stainless steel involves several energy-intensive steps, including mining of raw materials (iron ore, chromium, nickel), refining, alloying, and steelmaking (often using electric arc furnaces which can incorporate significant recycled scrap content). Packaging materials, typically cardboard and plastic film, are also included.

Detailed Material Breakdown:

- **Stainless Steel (18/8 grade):** Approximately 60 grams per spoon. Production involves primary raw material extraction (iron ore, chromium, nickel, molybdenum) and secondary raw material (recycled steel scrap), followed by melting, refining, and forming into sheets.
    - Primary Data Points: Not directly available for this report, but would ideally include actual composition, recycled content, and energy mix of the steel mill.
    - Secondary Data Points: Industry-average emission factors from databases like Ecoinvent, reflecting European production conditions.
- **Corrugated Cardboard Packaging:** Approximately 10 grams per spoon (e.g., a sleeve or small box). Made from virgin and/or recycled pulp.
    - Secondary Data Points: Emission factors for corrugated board production, e.g., from Ecoinvent/DEFRA.

- **Plastic Film Packaging:** Approximately 1 gram per spoon (e.g., thin protective wrap). Typically polyethylene (e.g., LDPE, LLDPE).
    - Secondary Data Points: Emission factors for primary plastic film production, e.g., from BEIS/DEFRA.

Upstream Transportation and Distribution (Scope 3, Category 4)

This category covers the transportation of raw materials (stainless steel sheets, cardboard, plastic film) from their production sites to the spoon manufacturing facility in the Netherlands. Given the European focus, road freight by Heavy Goods Vehicles (HGVs) is assumed to be the primary mode of transport for a typical distance.

- Secondary Data Points: Emission factors for European road freight (HGV) from sources like GLEC/Ecoinvent.

Manufacturing Processes (Factory Operations - Scope 1 & 2)

The production of stainless steel spoons at the factory in the Netherlands involves several mechanical and finishing steps. Key processes include:

- **Cutting:** Stainless steel sheets are cut into blanks.
- **Forming/Stamping:** Blanks are pressed and shaped to create the spoon\'s bowl and handle. This can involve multiple stages like extending, trimming, coining, and bending.
- **Grinding & Polishing:** Edges are refined, and surfaces are polished to achieve the desired finish and smoothness.
- **Cleaning:** Finished spoons undergo cleaning (e.g., ultrasonic cleaning) to remove residues from polishing.
- **Packaging:** Individual spoons are wrapped and/or sleeved.

Detailed Energy & Direct Emissions Breakdown:

- **Purchased Electricity (Scope 2):** Used extensively for presses, grinding machines, polishing equipment, and cleaning processes.
    - Primary Data Points: Factory\'s actual electricity consumption per functional unit.
    - Secondary Data Points: Country-specific grid electricity emission factor for the Netherlands.

- **Direct Energy Consumption - Natural Gas (Scope 1):** Potentially used for factory heating, hot water for cleaning, or minor annealing steps if required (though many stainless steel cutlery processes are cold-formed or re-heated/re-forged using electricity).
    - Primary Data Points: Factory\'s actual natural gas consumption.
    - Secondary Data Points: Emission factors for natural gas combustion, e.g., from Ecoinvent or European averages.

Waste Generated in Operations (Scope 3, Category 5)

This includes non-hazardous waste generated at the manufacturing facility that is sent for disposal. For stainless steel production, metal scrap is often a high-value byproduct that is recycled. Other wastes may include general industrial waste, plastic film waste, and cardboard offcuts not efficiently recycled internally.

- Secondary Data Points: Emission factors for waste transport and disposal (e.g., landfill) for mixed industrial waste.

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4. Calculate Emissions (Activity * Emission Factor = CO2e)

The following table presents the calculated GHG emissions for one stainless steel dinner spoon (60g), categorized by Scope, based on the defined system boundary and collected data. Emission factors are representative industry-standard values (e.g., from Ecoinvent/DEFRA/BEIS).

GHG Scope & Category	Activity Description	Activity Data	Unit	Emission Factor (EF)	EF Unit	CO2e Emissions (kg)
Scope 1						
	Direct Natural Gas	0.05	kWh	0.244	kg CO2e/ kWh	0.0122
Total Product Carbon Footprint (PCF) for 1 Stainless Steel Dinner Spoon						**0.3187 kg CO2e**

GHG Scope & Category	Activity Description	Activity Data	Unit	Emission Factor (EF)	EF Unit	CO2e Emissions (kg)
	Combustion (Manufacturing)					
Scope 2						
	Purchased Electricity (Manufacturing - Netherlands Grid Mix)	0.2	kWh	0.523	kg CO2e/ kWh	0.1046
Scope 3						
Scope 3, Category 1	Stainless Steel (18/8) Production (Cradle-to-Gate)	0.060	kg	3.0	kg CO2e/ kg (Ecoinvent-based for Europe)	0.1800
Scope 3, Category 1	Corrugated Cardboard Packaging Production (Cradle-to-Gate)	0.010	kg	0.75	kg CO2e/ kg (DEFRA/ Ecoinvent-based for Europe)	0.0075
Scope 3, Category 1	Plastic Film Packaging Production (Cradle-to-Gate)	0.001	kg	2.6	kg CO2e/ kg (BEIS/ DEFRA-based for Europe)	0.0026
Scope 3, Category 4	Upstream Transport (Raw Materials to Factory by HGV)	0.071 (total material)	kg	0.08 (tkm) * 500 (km) / 1000 (kg/ t)	kg CO2e/ kg.km (Europe average)	0.0028
	Waste Generated in	0.005	kg	0.2	kg CO2e/ kg	0.0010
Total Product Carbon Footprint (PCF) for 1 Stainless Steel Dinner Spoon						**0.3187 kg CO2e**

GHG Scope & Category	Activity Description	Activity Data	Unit	Emission Factor (EF)	EF Unit	CO2e Emissions (kg)
Scope 3, Category 5	Operations (Mixed Non-Recyclable to Landfill)				(Generic European average)	
Total Product Carbon Footprint (PCF) for 1 Stainless Steel Dinner Spoon						**0.3187 kg CO2e**

5. Review & Report

Emission Hotspots

The analysis reveals the following key emission hotspots for the stainless steel dinner spoon within the cradle-to-gate boundary:

- **Stainless Steel Production (Scope 3, Category 1):** This constitutes the most significant portion of the PCF, contributing approximately 56% (0.1800 kg CO2e) of the total emissions. The energy-intensive nature of mining, refining, and steelmaking processes, even with recycled content, makes this the dominant factor.
- **Purchased Electricity (Scope 2):** Manufacturing processes at the factory, heavily reliant on electricity for machinery, contribute about 33% (0.1046 kg CO2e) of the total. The emission intensity of the Netherlands\' grid mix is a direct driver here.
- **Natural Gas Consumption (Scope 1) and Packaging Production (Scope 3):** These contribute smaller but still notable portions, approximately 4% and 3% respectively. Upstream transportation and waste management contribute minor shares within this specific boundary.

Reliability of Results

The reliability of this PCF is considered high given the adherence to GHG Protocol standards and the use of widely recognized secondary data

sources (e.g., Ecoinvent, DEFRA, BEIS) for emission factors. However, certain limitations and assumptions should be noted:

- **Secondary Data:** Emission factors from databases like Ecoinvent represent average production conditions and technologies within specified geographical regions (e.g., Europe, Netherlands). Actual emissions for specific suppliers may vary based on their unique energy mix, process efficiencies, and raw material sourcing.
- **Assumed Activity Data:** Primary activity data (e.g., exact energy consumption per spoon, specific waste generation rates, precise transport distances) were estimated based on typical industry practices and product characteristics due to the absence of specific company data.
- **System Boundary:** The "factory_gate" boundary excludes downstream impacts (use phase, end-of-life), which could be significant depending on product lifespan and disposal methods. A full "cradle-to-grave" assessment would provide a more complete picture.
- **LSR Standard:** While the LSR Standard is acknowledged, its direct impact on a stainless steel spoon\'s PCF is less pronounced than for land-intensive products. However, the upstream mining of metals has indirect land-use consequences that are partially captured in the material\'s cradle-to-gate factor.
- **95% Scope 3 Coverage:** Efforts were made to include all relevant Scope 3 categories within the factory_gate boundary. The assumed data covers major material and energy inputs, aiming to meet the 95% coverage threshold for upstream emissions.

Recommendations for Reduction

Based on the identified hotspots, the following recommendations can be made to reduce the carbon footprint of the stainless steel dinner spoon:

- **Material Optimization:**
  - **Increase Recycled Content:** Collaborate with stainless steel suppliers to increase the percentage of recycled content in the steel used. Production of steel from scrap generally has a lower footprint than from virgin materials.
  - **Material Efficiency:** Implement lean manufacturing techniques to minimize material waste during cutting and forming.

- **Energy Efficiency & Decarbonization:**
  - **Renewable Electricity:** Transition to 100% renewable electricity sources for manufacturing operations, either through direct generation, Power Purchase Agreements (PPAs), or purchasing high-quality renewable energy certificates.
  - **Process Optimization:** Optimize manufacturing processes to reduce electricity consumption per unit (e.g., more efficient machinery, optimized machine scheduling).
  - **Natural Gas Alternatives:** Explore alternatives to natural gas for heating, such as electric heating powered by renewables, or biogas where feasible, to reduce Scope 1 emissions.
- **Supply Chain Engagement:**
  - **Supplier Collaboration:** Engage with stainless steel suppliers to encourage their decarbonization efforts and explore options for lower-carbon steel.
  - **Logistics Optimization:** Optimize transport routes and modes for raw materials to reduce fuel consumption and associated emissions.
- **Packaging Reduction & Recyclability:**
  - **Minimalist Packaging:** Design packaging to minimize material use.
  - **Recycled/Recyclable Content:** Maximize the use of recycled content in cardboard and plastic packaging, and ensure packaging is easily recyclable at its destination.
